Claims

[c1] A vertical ammonia converter, comprising:

a vessel having an upright cylindrical shell;

a plurality of fixed bed catalyst zones vertically spaced apart in the vessel, including uppermost and lowermost catalyst zones and at least one intermediate catalyst zone;

at least the uppermost and intermediate catalyst zones concentrically disposed about a respective shell and tube heat exchanger for interstage cooling of effluent gas from said catalyst zones;

magnetite catalyst disposed in the uppermost catalyst zone and high activity catalyst disposed in the intermediate and lowermost catalyst zones;

wherein at least the intermediate catalyst zones comprise at least two mechanically separated catalyst beds disposed vertically with respect to each other and configured for parallel downward gas flow split between the at least two catalyst beds.

[c2] The vertical ammonia converter of claim 1 wherein the lowermost catalyst zone comprises at least two mechanically separated catalyst beds disposed vertically with respect to each other and configured for parallel downward gas flow split between the at least two catalyst beds.

[c3] The vertical ammonia converter of claim 1 wherein the shell has a substantially uniform diameter along the length of the catalyst zones.

[c4] The vertical ammonia converter of claim 1 comprising respective pluralities of conduits passing through each respective catalyst bed to effect the parallel gas flow split.

[c5] The vertical ammonia converter of claim 1 comprising respective annular flow passages around each catalyst bed to effect the parallel gas flow split.

[c6] An ammonia converter, comprising:

an upright cylindrical shell;

at least one fixed bed zone disposed within the shell between an upper

gas inlet zone and a lower gas outlet zone and comprising upper and lower catalyst volumes configured for downward gas flow in parallel through each volume;
an annular housing for the catalyst volumes formed by inner and outer concentric shrouds around a shell and tube heat exchanger;
a partition plate in the annular housing disposed between the upper catalyst volume and the lower catalyst volume;
an upper discharge plenum formed between the partition plate and a catalyst support below the upper catalyst volume;
an intermediate inlet plenum formed between the partition plate and the lower catalyst volume;
a gas bypass for diverting a portion of the downward gas flow from the gas inlet zone past the upper catalyst volume to the intermediate inlet plenum above the lower catalyst volume;
a lower discharge plenum below a catalyst support at a lower end of the lower catalyst volume;
a discharge passage in fluid communication between the upper and lower discharge plenums and a shell-side fluid inlet to the heat exchanger;
a shell-side fluid outlet from the heat exchanger in fluid communication with the gas outlet zone.

[c7] The ammonia converter of claim 6 wherein the gas bypass comprises a first plurality of tubes passing through the upper catalyst volume and upper discharge plenum.

[c8] The ammonia converter of claim 7 comprising a second plurality of tubes passing through the intermediate inlet plenum and lower catalyst volume, and communicating between the upper and lower discharge plenums.

[c9] The ammonia converter of claim 8 wherein the outer shroud depends from an inverted support cone secured between the shell and an upper end of the outer shroud.

[c10] The ammonia converter of claim 8 wherein the discharge passage comprises an annulus between the inner shroud and a concentric intermediate shroud having

a larger diameter.

[c11] The ammonia converter of claim 6 wherein the gas bypass comprises an annulus between the outer shroud and the shell and a plurality of openings in the outer shroud into the intermediate inlet.

[c12] The ammonia converter of claim 11 wherein the outer shroud is supported on a support cone secured between the shell and a lower end of the outer shroud.

[c13] The ammonia converter of claim 12 wherein the discharge passage comprises an annulus between the inner shroud and a concentric intermediate shroud having a larger diameter.

[c14] The ammonia converter of claim 13 comprising a plurality of openings in the intermediate shroud between the upper discharge plenum and the discharge passage.

[c15] The ammonia converter of claim 12 wherein the fixed bed zone comprises a modular pre-assembly attached to the shell via the support cone.

[c16] The ammonia converter of claim 6 wherein the catalyst volumes are filled with catalyst.